The Application of Telemedicine Technology to a Directly Observed Therapy Program for Tuberculosis: A Pilot Project

James DeMaio,[1] Lawrence Schwartz,[1] Peggy Cooley,[2] and Alan Tice[1]

[1]Infections Limited, and [2]Tacoma-Pierce County Health Department, Tacoma, Washington

We evaluated the use of videophone technology to provide directly observed therapy (DOT) to patients with active tuberculosis. During 304 treatment doses, adherence on videophone DOT was 95%, and patient acceptance of the technology was excellent. In selected cases, the use of videophone technology can maintain a high level of adherence to DOT in a cost-effective manner.

Failure of patients to adhere to therapy for tuberculosis (TB) is a significant public health challenge [1]. The large pill burden, the length of treatment, and significant medication side effects all act as obstacles to completion of therapy.

Current Centers for Disease Control and Prevention guidelines set a goal of 90% for completion of a 6-month course of therapy within 12 months [2]. Unfortunately, reviews of self-administered TB programs reveal failure rates of 35%–58% worldwide [3–5]. In the United States from 1987 through 1991, an average of 25% of active cases failed to complete therapy in a timely manner [6].

Several advisory panels have recommended directly observed therapy (DOT) as a means to ensure patient adherence through the administration of all doses of medication by trained health department personnel [2, 7]. DOT has been shown to increase treatment completion rates, decrease relapses, and possibly reduce the overall incidence of TB [8–10]. This effect has been documented both in groups at low risk for nonadherence and also in high-risk groups, including substance abusers, homeless persons, and refugees [11, 12]. The World Health Organization DOTS program (directly observed therapy—short course) has shown that the DOT strategy may allow shorter courses of anti-TB therapy because of improved compliance [13, 14].

DOT is cost effective in the long term because of the prevention of relapses [5]. A DOT program, however, requires a substantial commitment of personnel time and public health resources. We examined the application of telemedicine to reduce the short-term costs of a DOT program in Pierce County, Washington.

DOT has been the standard of care in Pierce County, Washington for >10 years. Candidates for the telemedicine project were selected from active cases of TB treated within the county who had successfully completed at least 4 weeks of standard DOT with >90% adherence. Patients were excluded from the study if they did not have a touch-tone phone, did not have a television, or had a previous history of injection drug use. All patients signed informed consent prior to entering the trial.

ViaTV units (8 × 8, Inc.) with a 28K modem were used to establish 2-way videophone links between the patient's home and the health department. Each videophone unit was self-contained and required only a touch-tone phone and a television for use. The units were acquired at a cost of $200 each. All units were installed by health department personnel, and patients were provided with instruction in their use at home.

The videophone units were able to provide 2-way visual communication over standard phone lines with a frame rate of 8–15 frames/s. Although the resolution was less than television quality, the patient could be easily identified and observed swallowing the dose of medications.

Patients were called at prearranged times, and video linkage was established. The patient identified himself/herself and then displayed the daily dosage of medication. All pills were swallowed in full view of the camera. Date of treatment, time required for therapy, and any problems with the video linkage were recorded. Any scheduled videophone visit that could not be completed was considered a videophone treatment failure. Serum drug levels were not tested during the study.

Medications were dispensed monthly at the patient's routine visit to the Infections Limited Chest Clinic. Each day's dosage was separately packaged and dated. Cost estimates were derived from personnel costs that average $29.83/h, including benefits and taxes, and vehicle mileage costs of $0.325/mile. At the conclusion of the study, patients were given a brief questionnaire, to determine the patient's acceptance of videophone technology.

Received 10 May 2001; revised 11 July 2001; electronically published 6 November 2001.

Financial support: All funding was provided by the Tacoma-Pierce County Health Department, Tacoma, Washington.

Reprints or correspondence: Dr. James DeMaio, Infections Limited, 1624 S. "I" St., Tacoma, WA 98405 (jdemaio@idlinks.com).

Clinical Infectious Diseases 2001;33:2082–4

© 2001 by the Infectious Diseases Society of America. All rights reserved.

1058-4838/2001/3312-0022$03.00

Six patients who met the inclusion and exclusion criteria were entered into the trial from 1998 through 2000. The adherence rate on standard DOT (S-DOT), the adherence rate on videophone DOT (V-DOT), mileage saved, and personnel time saved for each patient are recorded in table 1.

A total of 246 episodes of S-DOT and 304 episodes of V-DOT were recorded. The average time required for a S-DOT visit was 1 h, compared with 3 min for a V-DOT visit. The use of S-DOT instead of V-DOT would have required an extra 288 h of personnel time. V-DOT required a total time of 20 h. Six of these hours were spent setting up the system in the patient's home, with a further 14 h required for actual V-DOT visits.

The distance driven for a S-DOT visit averaged 30.6 miles round trip (range, 20–46 miles). A total of 8830 miles of travel were avoided during the study.

Patient adherence to therapy was 97.5% on S-DOT and 95% on V-DOT. Sixteen doses of V-DOT were missed; in 6 of these cases, the patient was not at home at the time of the scheduled call, and in 9 of the cases, a connection could not be established over the phone lines. A further 3 doses of V-DOT were temporarily delayed because of interruptions in the video linkage. In all 3 of those cases, V-DOT was successfully completed. Although the follow-up period has been short, no episodes of disease relapse have occurred in patients treated by use of V-DOT.

Five of the 6 patients completed a brief questionnaire after completing the DOT program. Patients were asked to rate the complexity of the technology, the level of convenience, the level of intrusiveness, and their overall level of satisfaction with V-DOT. All ratings were on a scale of 1–10, with 1 being very unsatisfactory and 10 being very satisfactory. All patients felt that V-DOT was more convenient and less intrusive than S-DOT (average satisfaction scores, 8.8 and 8.4, respectively). Patients found videophone technology easy to master (average satisfaction score, 8.4). Overall satisfaction with V-DOT was very high (average satisfaction score, 9.2), compared with S-DOT.

Telemedicine allows patients and health-care providers to interact both verbally and visually over large distances. This technology has been successful in improving patient care in pulmonary, geriatric, and rehabilitation medicine [15–17]. The current study demonstrates that telemedicine is directly applicable to DOT for TB.

V-DOT insured a high degree of adherence (95%) to the treatment regimens. If it were not for technical problems (9 events), the adherence on V-DOT would have been 98%. The technology was relatively simple and easily explained to patients. The difficulties encountered in maintaining video linkage may well be eliminated by improving technology or by more sophisticated, albeit more expensive, equipment.

Table 1. The adherence rates on standard directly observed therapy (S-DOT), adherence rates on videophone DOT (V-DOT), mileage saved, and reduced health department personnel time for patients with active tuberculosis in a V-DOT pilot program.

	Patient no.						
Variable	1	2	3	4	5	6	Total
S-DOT							
Doses completed	48	27	22	47	67	29	240
Total doses	49	27	22	48	70	30	246
Adherence, %	98	100	100	98	96	97	97.5
V-DOT							
Doses completed	142	39	56	27	7	17	288
Total doses	150	39	59	31	7	18	304
Adherence, %	95	100	95	87	100	94	95
Mileage saved	4260	1638	1120	810	322	680	8830
Travel time saved, h	121	67	43	26	10	21	288

The V-DOT program realized a substantial cost savings. The total cost for the videophone equipment (5 units) was $1000. This cost was easily offset, with a savings in travel expenses of $2870 and personnel expenses of $7993.

The most significant advantage of telemedicine is that it makes the distance between the patient and the health-care provider meaningless. V-DOT will have its largest affect in areas with widespread patient populations. Patients in rural areas can rapidly gain access to expert TB care without regard to transportation.

Patient acceptance of videophone technology was high. All patients felt that V-DOT was much less intrusive than S-DOT. Videophone visits were brief, lasting only 2–5 min, and allowed tremendous flexibility in scheduling. This flexibility was convenient both for patients and for health department personnel. Visits could be scheduled around work hours and by staff who started work early or ended work late.

Current videophone technology does have some limitations. The slow modem speed (28K) in our units led to a grainy picture at low levels of light. Care was required to provide adequate lighting in the patient's home, and the cable connection had to be short. Transmission quality should improve in the future as this technology evolves. Eventually, telemedicine may be able to use devices already owned by the patient, such as computers with video attachments or television sets with interactive capabilities.

The successful application of telemedicine to DOT for TB requires careful patient selection. It would be possible for a patient to place the pills in his or her mouth while on camera but not swallow the pills. We have had nonstudy patients on S-DOT attempt to "cheek" (e.g., pretend to swallow) the medications in the past. V-DOT is most appropriate for patients who have demonstrated prior good adherence and who simply

need a reminder to take their medication. V-DOT is not appropriate for patients who are making an active effort to avoid therapy. Patients in unstable social situations, such as the homeless and substance abusers, are also poor candidates.

Language barriers may pose another obstacle in some cases. The need for translators is a particular problem in our county, where 53% of the active TB cases over the past 4 years have been in immigrants. Despite these limitations, we believe that 26 (35%) of the 75 patients treated in our county over the past 2 years would have been potential candidates for V-DOT.

Telemedicine offers an opportunity to maintain a high level of adherence to DOT for TB in a cost-effective manner. The cost savings from V-DOT can be applied to much-needed screening and intervention programs for TB.

Acknowledgments

We thank Federico Cruz-Uribe, MD, and Dian Sharma, PhD, for their enthusiastic support of this project. We thank Pam Hoaglund for her assistance in editing the manuscript.

References

1. Addington WW. Patient compliance: the most serious remaining problem in the control of tuberculosis in the United States. Chest **1979**; 76(Suppl 6):741–3.
2. Centers for Disease Control and Prevention. Improving patient adherence to Tuberculosis Treatment. Rev. ed. Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services, Public Health Service, **1994**.
3. Jin BW, Kim SC, Mori T, et al. The impact of intensified supervisory activities on tuberculosis treatment. Tuber Lung Dis **1993**; 74:267–72.
4. Snider DD, Lon MW, Cross FS, et al. Six-month isoniazid-rifampin therapy for pulmonary tuberculosis: report of a United States Public Health Service cooperative trial. Am Rev Respir Dis **1984**; 129:573–9.
5. Moore RD, Chaulk CP, Griffiths R, et al. Cost-effectiveness of directly observed versus self-administered therapy for tuberculosis Am J Respir Crit Care Med. **1996**; 154:1013–9.
6. Centers for Disease Control and Prevention. Tuberculosis program management in the United States 1986–1991. Atlanta, GA: Centers for Disease Control and Prevention, **1993**.
7. American Thoracic Society, Medical Section of the American Lung Association. Treatment of tuberculosis and tuberculosis infection in adults and children. Am J Respir Crit Care Med **1994**; 149:1359–74.
8. Westaway MS, Conradie PW, Remmers L. Supervised out-patient treatment of tuberculosis: evaluation of a South African rural programme. Tubercule **1991**; 72:140–4.
9. Wilkinson D. High compliance tuberculosis treatment programme in a rural community. Lancet **1994**; 343:647–8.
10. Chaulk CP, Moore-Rice K, Rizzo R, et al. Eleven years of community-based directly observed therapy for tuberculosis. JAMA **1995**; 274: 945–51
11. Schluger N, Ciotili C, Cohen D, et al. Comprehensive tuberculosis control for patients at high risk for noncompliance. Am J Respir Crit Care Med **1995**; 151:1486–90.
12. Sukrakanchana-Trikham P, Puechal X, Rigal J, et al. Ten-year assessment of treatment outcome among Cambodian refugees with sputum smear-positive tuberculosis in Khao-I-Dang, Thailand. Tuber Lung Dis **1992**; 73:384–7.
13. Norval PY, San KK, Bakhim T, et al. DOTS in Cambodia. Directly observed treatment with short-course chemotherapy. Int J Tuber Lung Dis **1998**; 2:44–51.
14. Dye C, Garnett GP, Sleeman K, et al. Prospects for worldwide tuberculosis control under the WHO DOTS strategy. Directly observed short-course therapy. Lancet **1998**; 352:1886–91.
15. Miyasaka K, Suzuki Y, Sakai H, et al. Interactive communication in high-technology home care: videophones for pediatric ventilatory care. Pediatrics **1997**; 99:E1
16. Nakamura K, Takano TM, Akao C. The effectiveness of videophones in home healthcare for the elderly. Med Care **1999**; 37:117–25.
17. Vesmarovich S, Walker T, Hauber RP, et al. Use of telerehabilitation to manage pressure ulcers in persons with spinal cord injuries. Adv Wound Care **1999**; 12:264–9.